

Title of the Invention:

EXHAUST GAS PROCESSING SYSTEM

Background of the Invention:

5 <Technical Field>

The present invention relates to an exhaust gas processing apparatus in which a decomposition and a chemical reaction etc. of a harmful chemical substance of an exhaust gas etc. which is exhausted from a boiler including NOx, a particle substance and hydrocarbon and an engine etc. are promoted and relates to a chemical work and an environment machine and apparatus etc..

<Prior Art>

Up to now, a processing technique having a low cost and for processing effectively NOx in an exhaust gas and fine particles in a harmful substance has not established. As a removal technique for NOx, a denitration technology using an ammonia is established as a fixed machine of a boiler and an engine but this technique has not employed in a moving machine such as an automobile from an aspect of the safety.

To NOx removal for a diesel vehicle it is taken a measure with a high pressure injection of the engine and a figuration of a combustion chamber but with only this measure a satisfied technology has not established.

There is a device in which as to NOx in the exhaust gas using a noble metal catalyst such as platinum and paradigm etc. NOx is generated and using a catalyst in a post-process the fine particles are decomposed but NOx  
5 reduction effect has been low about 15 % degree and a regular processing apparatus has not established.

Further, there is a three way catalyst in which the noble metal is contained mainly but this catalyst has been the high cost and is not employed to be practical use. In  
10 this, since the platinum used in the catalyst is lowered the catalyst function due to the sulfur in the fuel, a spread of a low sulfur fuel is set as premise.

On the other hand, as the removal technique for the fine particles a technique, in which the above stated  
15 oxidation decomposition using NO<sub>2</sub> the noble metal such as platinum is low temperature decomposed, has established but this technique is invited the high cost and then the regular spread has not attained.

Now, a method for processing, in which using a  
20 ceramic filter the fine particles are adsorbed and after the adsorption this is processed with the combustion, has established. However, a batch processing and an alternative processing system in a plural processing system have established but since this is invited the high cost  
25 and the badness in the usability, the regular spread is obstructed.

In the diesel engine, according to the operation condition, the components in the harmful substance in the exhaust gas changed largely, the method in which all the present processing apparatuses are followed and processed and an apparatus in which the processing function lowering is regenerated and processed in a real time is not realized.

It is established a technique wherein, without the affect of sulfur, using the discharge, NO of NOx in an exhaust gas is decomposed completely and a necessary NO<sub>2</sub> for oxidizing the fine particles under a low temperature of about 300 C is generated in a real time.

It is established a technique wherein the generated NO<sub>2</sub> and the ozone generated in an oxygen atmosphere and an active oxygen are used as an oxidation agent, the particle substance is composed completely using a low cost catalyst under a low temperature about 300 C or not using completely the catalyst.

It is established a technique wherein by following an operation condition of the engine, a processing is carried out in a real time.

It is established a technique wherein a construction having a low cost and a durability performance is attained.

It is established an apparatus in which an ammonia generation means is accompanied independently and the processing of NOx etc. is functioned effectively.

It is established a technique about a generator system having a high heat resistance and a superior efficiency wherein when an exhaust gas is processed according to a discharge and an electric application, an additionally electric capacity is compensated and it has been a compatibility with an already established generator.

#### Summary of the Invention:

(1) As a solving measure for the technique wherein, without the affect of sulfur, using the discharge, NO of NOx in an exhaust gas is decomposed completely and a necessary NO<sub>2</sub> for oxidizing the fine particles under a low temperature of about 300 C is generated in a real time.

Firstly as a means for carrying out without receipt of the affect of sulfur in the fuel, the generation of NO<sub>2</sub> is carried out not using platinum as the catalyst. Namely, the barrier discharge etc. is used.

As a concrete example, to lower the voltage applied to the electrode as possible, one of the electrodes is formed with a long line shape, a belt shape, a rod shape, or a plate shape, and an outer skin of a superior permeability performance and thin insulation body such as a ceramic, and a heat resistance silicone etc. is covered.

Another of the electrodes is formed with a bear wire suited to a shape of the insulation core wire and along to

the insulation core wire is arranged closely in a parallel shape, a rectangular shape, a spiral shape, a net shape, or a zigzag shape and then the ozone and the barrier discharge is generated effectively.

5       The alternating current high voltage is applied to the electrodes and the voltage and the frequency number are changed, in conform to the raise of the voltage, NO in an exhaust gas containing a residual oxygen is lowered and it has became zero when it is reached to same voltage.

10       On the other hand, NO<sub>2</sub> is increased gradually slightly (less than 1/10) at first in comparison with NO and NO<sub>2</sub> is existed in a range of zero and it is shown a peak value and when the voltage is lowered further it is reduced gradually and becomes zero soon. At this time  
15 point, NO<sub>x</sub> is gone out of existence completely.

In this case, the more an oxygen concentration and a hydrocarbon concentration is high, the more a range for vanishing completely NO and NO<sub>x</sub> is existed wide. Namely, it is possible to make the energy of NO<sub>x</sub> decomposition  
20 small and is carried out the stable processing. By controlling the oxygen concentration and the hydrocarbon concentration, it is possible to obtain from a V curve to a reverse trapezoid curve having long bottom face.

In the exhaust gas processing system, when the above  
25 stated concentrations are controlled, it is possible to

carry out a further stable exhaust gas processing. Further, when the voltage is increased further, in some voltage NO is increased from zero and NO<sub>2</sub> is shifted to increase, it is possible to obtain an increase characteristic.

5 By applying this phenomenon, in the range of NO being zero, it is possible to control in a moment of time a range from a peak value to zero according to a slight change of the voltage. By following the operation of the engine and by suiting an amount of the particle, NO<sub>2</sub> necessary for  
10 converting to NO<sub>2</sub> is generated in a real time. This control is carried out in a small area and a high area of the discharge energy.

It is necessary to set a discharge element and a power supply means suited to the size of the engine and the  
15 operation condition and a capacity of the means necessary to the control. When the barrier discharge in this example is used, in the discharge element of 80 cm, it is possible to process with a comparatively low voltages of 18 kHz, 6.5 kv degree and a small consumption electric power of from 10  
20 W to 20 W.

Further, in a case of the spiral shape discharge wire, as shown in Table 1, it is resulted that a winding pitch of about 10 mm is obtained the most superior decomposition efficiency.

(2) As a solving measure of the technique wherein the generated  $\text{NO}_2$  in the above stated item (1) and the ozone generated in an oxygen atmosphere and an active oxygen are used as an oxidation agent, the particle substance is decomposed completely using a low cost catalyst under a low temperature about 300 C, since the amount of  $\text{NO}_2$  and the ozone (more than 400 C, this has become the active oxygen) is controlled freely with the voltage, the frequency number and the oxides of vanadium and molybdenum, the zeolite and the alumina are used as the catalyst and under the low temperature about 300 C, without of the bare use of the noble metal the particle substance is decomposed completely.

Further, using the nitric acid which is formed by the generated  $\text{NO}_2$  and the water in the gas and the sulfur oxide such as sulfuric acid which is formed by the oxidation of sulfur in the fuel, without the catalyst it is possible to decompose the particle substance and to control the generation amount of  $\text{NO}_2$ .

(3) A solving measure of the technique wherein by following the operation condition of the engine and it is carried out in the real time, using  $\text{NO}_2$  control technique stated on the above item (1), by following to the operation condition of the engine, the necessary  $\text{NO}_2$  amount is calculated using the sensor and the operation

characteristic or is generated immediately and then the particle substance is decomposed completely.

A particle substance sensor is arranged in an inlet port of the processing apparatus, the particle substance is sensed in the real time, and the information thereof is inputted to a controller.

On the other hand, in before and after of a flow passage of the processing apparatus, NOx sensor or NO<sub>2</sub> sensor is arranged, and it is grasped that whether the concentration of after the pass-through of the processing apparatus has been in an increase condition or in a decrease condition, NO<sub>2</sub> amount for necessary to the complete decomposition of the particle substance is calculated according to NOx concentration and NO concentration after the processing.

The voltage value suited to the necessary energy is determined and the voltage is controlled in the real time, as a result NOx and the particle substance are removed completely.

(4) A solving measure for attaining the above stated items (1)-(3) with the low cost structure, in the exhaust gas processing system according to the present invention, three large material elements in the cost aspect are existed and these three material elements have been the discharge element, the low temperature catalyst, and the control means.



Firstly, as the discharge element, this element has been a simple structure in which around the thin and long discharge core wire the discharge wire is arranged with the spiral shape, for example. With the technique for manufacturing the optical fiber and the electric wire, the large amount discharge elements are manufactured simple and the discharge element having the superior reliability is manufactured.

Next, as to the catalyst, as stated in the above stated item (2), in basically without the use of the noble metal wholly, it is realized the use of about a few amount of 0.2 % in the weight percentage and to the oxides of vanadium and molybdenum having the comparative low cost since the alumina and the zeolite are coexisted, compared with the conventional catalyst in which the noble metal is main, it is settled with the very low cost.

(5) As to the ammonia generation means for generating the ammonia independently and the construction for functioning the effective NOx processing, obtaining N<sub>2</sub> gas in air and the moving vehicle having hydrogen supply means generated in the fuel battery etc., and using N<sub>2</sub> and the hydrogen and then the ammonia is generated, it is possible to make harmless one according to NOx processing technique which is carried in the fixed means.

(6) When the exhaust gas is processed by employing the discharge and the electric power application, the additional electric capacity is compensated and the generator having the heat resistance performance and the superior efficiency is constructed to the system in which the compatibility is formed with the already established generator.

As to the above stated construction system, the inventor of the present invention has devised that using the generator having the low start activation torque, more than the high efficiency (95 %), using the slot insulation which is enable to arise the use temperature from 500 C from the conventional temperature of 250 C and to the insulation portion of the covering of the coil the ceramic such as alumina it is possible to realize the compatibility with the already established generator.

#### Brief Description of Drawings:

Fig. 1A is a cross-sectional explanatory view showing an exhaust gas processing apparatus in which the concentration of NOx is controlled by the high voltage discharge according to the present invention and in the catalyst unit of the post-process it enable to follow the dynamic change in the engine etc..

Fig. 1B is a cross-sectional explanatory view showing an exhaust gas processing apparatus according to the prior

art in which in the before stage and the after stage the catalyst using the noble metals are used.

Fig. 2A and Fig. 2B are explanatory views each showing a discharge portion of a discharge wire in which an insulation core wire is arranged in parallel.

Fig. 2C and Fig. 2D are explanatory views each showing a discharge portion of a discharge wire in which an insulation core wire is arranged with a spiral shape.

Fig. 2E and Fig. 2F are explanatory views each showing a discharge portion of a discharge wire in which an insulation core wire is arranged with a net shape.

Fig. 3 is a NO<sub>x</sub> (NO, NO<sub>2</sub>) reduction characteristic explanatory view of a spiral shape discharge portion according to the present invention.

Fig. 4A is an explanatory view showing a general exhaust gas processing apparatus having a means for processing the particle substances employing a low voltage discharge of an embodiment according to the present invention.

Fig. 4B is a selective and all-inclusive explanatory view showing an apparatus for processing the particle substances employing a low voltage discharge according to the present invention.

Fig. 5A is NO<sub>x</sub> reduction characteristic view according to a discharge in an oxygen concentration of 10 % in the exhaust gas.

Fig. 5B is NOx reduction characteristic view according to a discharge in an oxygen concentration of 15 % in the exhaust gas.

Fig. 5C is NOx reduction characteristic view according to a discharge in an oxygen concentration of 18 % in the exhaust gas.

Fig. 5D is NOx reduction characteristic view according to a discharge in an oxygen concentration of 21 % in the exhaust gas.

Fig. 6 is an explanatory view showing a sensing method in a case where the reduction of NOx is controlled.

Fig. 7A is a structure explanatory view of a discharge wire in which plural wires are combined to maintain the performance of the discharge wire.

Fig. 7B is a side cross-sectional view of a discharge wire shown in Fig. 7A.

Fig. 7C is an explanatory view showing a method for changing the pitch in a case in which the discharge characteristic is changed.

Fig. 7D is an explanatory view showing an example of an insulation structure of the insulation core wire.

Fig. 7E is an explanatory view showing another example of an insulation structure of the insulation core wire.

Fig. 8A is NOx reduction characteristic view showing a discharge in which an oxygen concentration is 10 % and C<sub>2</sub>H<sub>4</sub> concentration is 1000 ppm in the exhaust gas.

Fig. 8B is NOx reduction characteristic view showing  
5 a discharge in which an oxygen concentration is 21 % and C<sub>2</sub>H<sub>4</sub> concentration is 1000 ppm in the exhaust gas.

Fig. 9 is an explanation view showing an example of an exhaust processing machine in which the heat retaining and the combustion same the reaction are carried out  
10 effectively.

#### Description of the Invention:

Hereinafter, the examples of the carrying out embodiments according to the present invention will be  
15 explained referring to the drawings. Fig. 1A is an exhaust gas processing apparatus of one embodiment according to the present invention and Fig. 1B is an exhaust gas processing apparatus of one embodiment according to the prior art.

The features of the present invention are classified  
20 largely to two processing units, in a pre-process a processing according to a barrier discharge is carried out and in a post-process a processing using a catalyst is carried out.

In the barrier discharge, to a long and narrow single  
25 insulation core wire or plural insulation core wires 2, a

bear discharge wire 3 is adhered closely on a surface of an insulation body and is netted with a spiral type and a cloth type as shown an example and is gotten across all over a space.

5           An end portion of the discharge wire 3 is connected to a ground earth 4 and between the insulation core wire a barrier discharge is generated effectively according to a supply power control unit 11 in which a high frequency and high voltage generation means is installed in an interior  
10   portion.

          In a high frequency and high voltage supply power using this means, the sine wave is formed to have a pulse shape and the voltage may be formed the same from a power aspect and the voltage may be arisen.

15           A sensor 10 detects the operation condition of an engine and detects directly the particle substance and NOx. A rotation number of the engine may be carried out using another means (not shown in figure).

          In this discharge unit, NOx exhausted from the engine  
20   etc., in particular NO and NO<sub>2</sub>, is decomposed completely and according to the changes of the voltage, the frequency number and the waveform, NO is decomposed completely and NOx is produced only and amount of thereof is controlled.

          It will be explained in Fig. 3 in a latter portion,  
25   for example, with a slight change of the voltage, the characteristic of NOx is changed largely to realize a very

small electric energy. Further, the structure of the discharge wire is constituted with a very simple electric wire and an optical fiber manufacture technique, the manufacture thereof is attained with a high reliability and  
5 the cost has been very cheap.

In the present invention,  $\text{NO}_2$  is generated by detecting the amount necessary for oxidizing the particle substance in the post-process using the oxidation property gas. As to this fact, the conventional apparatus has been  
10 no control function.

Namely, the discharge unit according to the present invention can be grasped exactly the condition of the engine and also the generation of the decomposition suited to  $\text{NO}_x$  on the condition is followed in a real time.

15 In the conventional apparatus shown in Fig. 1B, since the large amount platinum being the noble metal has used as the catalyst it is invited the high cost and further according to the affect of the sulfur in the fuel the function is lowered.

20 Next, the catalyst processing unit in the post-process will be explained. In this unit, the catalyst in which mainly the particle substance is decomposed completely is used in the low temperature of about 300 C. For example, the comparatively low cost catalyst such as  
25 the oxide of vanadium 5 and the oxide of molibudiam and alumina or the zeolite 7 is used and  $\text{NO}_2$  is worked

effectively and then the substance is decomposed completely. These catalysts is realized almost with no use of the noble metal.

A reference numeral 1 is a frame of the machine and  
5 apparatus and a reference numeral 8 is a partition wall having a superior permeability performance for holding the catalyst.

The conventional exhaust processing apparatus shown in Fig. 1B will be explained. In the pre-process, the  
10 large amount platinum 5a, paradigm 6a and alumina 7a is used and NO in NOx is oxidized to NO<sub>2</sub> and in the catalyst in the post-process the particle shape substance is oxidized harmlessly. Since the noble metal is used, it is invited the high cost and the spread is obstructed greatly.

15 In this catalyst system, against to the operation of the engine etc., for example by following the generation condition of the particle substance, it is impossible to carry out the processing and it is impossible to take the measure to the affect and the detoriation of sulfur.

20 The removal of NO is not carried out completely and NO of 85 % is discharged from an exhaust port. This can be said that it has been the incompleteness apparatus. In the post-process, the noble metal is used mainly as the catalyst and the platinum 5b, paradigm 6b and alumina 7b is  
25 used and the processing is carried out.



A reference numeral 1a is a frame of the machine and apparatus, and a reference numeral 8a is a partition wall having a superior permeability performance for holding the catalyst.

5        Figures from Fig. 2A to Fig. 2F will be explained. Herein, an example of the discharge wire structure being a base component of the present invention is shown. Fig. 2A and Fig. 2B show the long and narrow insulation core wire which is constituted by a core wire 22a and an insulation  
10    body 2a which is made by a material having a superior ductility performance and thin and tuff material such as a ceramic and a heat resistance silicon rubber which is covered an outer skin of the core wire 22a.

      An electrode is formed by the insulation core wire  
15    and a thin and bear discharge wire 3a having a diameter of from 0.2 mm to 0.3 mm which is arranged closely to this insulation core wire. An insulation body 17a is used for the electric isolation when the bear wire is drawn out the outer portion of the apparatus and machine.

20        With the above stated simple structure, the manufacture method having the high reliability performance such as the electric wire and the optical fiber is utilized and it is possible to manufacture the discharge wire having the low cost and the high performance. This is the  
25    material having a superior ductility performance in which

the zirconium is blended to the alumina and also having superior insulation performance.

Fig. 2C and Fig. 2D show an example in which the discharge wire 3b is arranged with a spiral shape against the insulation core wires 2b and 22b. When a pitch of the spiral is changed, the decomposition performance of NOx is changed largely and it is possible to manufacture the substances suited for the exhaust gas decomposition of the engine etc.. A reference numeral 17 is an insulation body.

Next Fig. 2E and Fig. 2F will be explained. The discharge wire 3c is assembled with a net shape and to the insulation core wires 2c and 22c the discharge wire is arranged with a cylindrical shape. By the cylindrical discharge wire, the discharge wire has become strong and has been the high durability performance and further in addition to the conducting body, for example it is possible to net using the ceramic wire including the glass and the alumina. To this ceramic the catalyst is burdened and the ozone and the active oxygen are generated effectively.

Further, in the same time of the NO<sub>2</sub> generation, the particle substance is decomposed and is processed all at once. As a result, the decomposition of the exhaust gas is carried out.

When a pitch of the spiral discharge wire is changed, the decomposition performance of NOx is changed largely and

it is possible to manufacture the substance suited for the exhaust gas decomposition of the engine etc.. The deterioration in the discharge wire is prevented and taking into the consideration under the severe condition the superior durability performance is attained. A reference numeral 17c is an insulation body.

Further, it is possible to combine the plural discharge wires in parallel or crossing. It is possible to wind the discharge wire having plural pitches to the insulation wire and to connect the poles of the end portion or to separate. Then the discharge performance having the different characteristic is formed on the single discharge wire and the durability performance is improved to have several times.

Fig. 3 shows one example of the characteristic of the NOx decomposition of the spiral discharge wire against the alternating current application voltage. By the changes of the voltages, the condition of the changes of NOx, NO and NO<sub>2</sub> will be understood.

NO is reduced abruptly in company with the voltage rise and is vanished completely in 6 kV and is continued zero (0) until 7.5 kV and further when the voltage is arisen the concentration is increased gradually. When NO is zero (0) condition, NOx is presented only NO<sub>2</sub> condition and between from 6.5 kV to 7.5 kV, it is changed abruptly with a V shape between from 130 ppm to zero.

Accordingly, utilizing this characteristic, it is attained the complete processing of NO and is shown the possibility about the decomposition of the particle substance without the residual NOx. By suiting the combustion condition of the engine and the boiler the harmful exhaust gas has become completely the harmless one in the real time.

In the conventional apparatus and machine, it is impossible to carry out the adjustment, even in some condition the most suitable characteristic may be obtained, but it is impossible to follow the concentration change of the harmful substance in the exhaust gas in accompany with the largely changed operation condition. Further, as to the characteristic deterioration in the use condition no solving measure is existed.

Fig. 4A shows the apparatus having the sensing function in which the particle substance is processed in the real time and further the processing waste is monitored always and is processed using the plural adsorption faces of a ceramic filter 60.

Between the electrode plates 61 which are provided on both end faces of the ceramic filter 60, mainly the condition of the adhesion of the carbon system particle substance is grasped, for example, according to the change in the electric resistance.

When the resistance value has become less than a predetermined value, the electric power is applied and then the particle substance is oxidized. The power supply for the electric supply has been very low voltage such as a  
5 several voltage (V) and in the automobile etc. it can be employed the power supply of the battery and the dynamo.

The processing of the particle substance is down simple and is processed in the real time, and further it is invited the low cost and the system having the superior  
10 durability performance is constructed. To the ceramic filter the lower temperature catalyst for NOx decomposition is used, for example in which alumina, the oxides of gallium, tin, and indium are burdened, only this process the harmful substance in the exhaust gas is processed.

15 Next, a catalyst processing unit in an intermediate process will be explained. This catalyst processing unit is constituted with NOx processing use catalyst and is constituted with the alumina 5c, oxides of gallium 6c, tin, and indium 7c etc..

20 An ammonia generation means 30 is provided in an exterior portion or in an interior portion and then an amount for necessarily process for use is supplied from a nozzle 31. It is possible to employ the plasma technique and the high pressure synthesis technique.

25 As stated in above, the denitration system which have established from the technical aspect in the present time

can be formed. For the ammonia generation, hydrogen and nitrogen has been necessary, but hydrogen is made from the water such as the cooling water of the engine using the electrolytic process and nitrogen is taken from the air, in  
 5 this time it is unnecessary to furnish the material supply.

Next, a final process in this figure is a discharge processing unit and this is mounted for the residual NOx processing and can be utilized as a part for the above stated ammonia generation.

10 A reference numeral 2d is an insulation core wire, a reference numeral 3d is a discharge wire, and a reference numeral 11a is a high voltage generating portion. A reference numeral 1b is a frame.

Reference numerals 70 and 71 are NOx sensor and NO<sub>2</sub>  
 15 sensor and they are installed in a suitable position in before or after the processing of NOx processing unit. They have sensed NOx processing condition in the discharge unit and adjust the voltage for necessary to carry out NOx removal and the frequency number and further control the  
 20 electric energy. A control method will be explained referring to Fig. 6.

Fig. 4B shows one example of a processing unit of the electric particle substance. In this figure, the resistance which is accompanied with the adhesion of the  
 25 particle substances between the electrodes 61a which are provided in both ends of a ceramic filter 60a is processed

by a sensor detection control portion 50 and between the electrodes necessary for particle substance processing the signal is sent to a burn-up processing control portion and is processed.

5 Switch portions 54 and 54a are opened or closed by the signal line 53 and the unevenness of the particle substances due to the place is gotten rid of. The high performance particle substance processing apparatus having the self-help function and being low cost is provided. A  
10 reference numeral 40a is a power supply terminal.

Fig. 5 shows an explanation of an example in which when the diesel exhaust gas is decomposed with the high voltage discharge the decomposition of NOx is changed extremely according to the oxygen concentration in the gas.

15 Fig. 5A shows a decomposition of the voltage - NOx (NO and NO<sub>2</sub>) during the oxygen concentration in the exhaust gas of 10 % and in accompany with the voltage arise NO is decomposed at first and in the vicinity of the voltage of 6.5 kV it is presented the lowest and more than this value  
20 it is increased gradually.

On the other hand, NO<sub>2</sub> is increased in an anti-proportion to the reduction of NO and is changed almost from the vicinity of 6 - 6.5 kV.

Fig. 5B shows a decomposition of the voltage - NOx  
25 (NO and NO<sub>2</sub>) during the oxygen concentration in the exhaust

gas of 15 % and NO is decomposed and vanished until the vicinity of the voltage of 5.5 kV and in turn NO<sub>2</sub> is increased abruptly.

NO is vanished gradually from 5.5 - 6.5 kV and has  
 5 became zero (0) the zero (0) condition is continued to the voltage of 7.5 kV and more than this the generation is caused again and in accompany with the increase of the voltage it is increased.

On the other hand, NO<sub>2</sub> is increased slightly between  
 10 the voltage of 5.5 - 6.5 kV and after the highland condition is continued and is reached to a peak and after the voltage of 6.5 kV it is shifted to the reduction and in the vicinity of 7 kV it is shown the minimum value and after that is shifted to the increase. In the boundary of  
 15 7.5 kV in accompany with the increase of NO it is shifted to reduce again.

Fig. 5C shows a decomposition of the voltage - NO<sub>x</sub> (NO and NO<sub>2</sub>) during the oxygen concentration in the exhaust gas of 18 % and NO and NO<sub>2</sub> is vanished together with and a  
 20 V curve line is appeared extremely. Between the voltage of from 6.5 kV to 7 kV, it is possible to vanish completely.

A range of the complete vanish is spread from the voltage 5.6 kV to the voltage of 7.5 kV. Utilizing this characteristic it is possible to vanish completely NO<sub>x</sub>.



In this case, since the oxygen concentration in the exhaust gas exhausted from the diesel engine has been substantially 16 %, by the provision of the oxygen supplying means in an outer portion of the system in the apparatus and machine, the effect means for reducing NOx is constructed.

Fig. 5D shows a decomposition of the voltage - NOx (NO and NO<sub>2</sub>) during the oxygen concentration in the exhaust gas of 21 % and NOx reduction characteristic is exhibited remarkably that of the oxygen concentration of 18 %.

As stated in above, when the oxygen concentration in the exhaust gas is changed, it is possible to control easily the reduction of NOx. When the oxygen concentration is increased further, and the substance which is formed the active oxygen condition and the ozone condition are supplied the reaction has become remarkably and the characteristic controls and it is invited the energy saving effect and with the small energy the removal of NOx is attained.

Fig. 6 is an explanation view showing a control method for determining the energy necessary for NOx processing by grasping the processing conditions in NOx processing apparatus. The sensors are arranged in a suitable position in before and after the flow passage of the discharge element in NOx processing apparatus and the processing condition of NOx is grasped.

Namely, the reduction decay of NOx or the increase decay of NOx are caught by the two sensors, and for example, when the reduction condition is presented from A point to B point, the energy is increased, and when from D point to C point it is changed, the energy is lowered, as a result the control is carried out surely and NOx is gotten completely rid of to remove. As occasion demands, the oxygen concentration adjustment apparatus in the system is tied up.

Fig. 7 shows an example of a new structure of the insulation discharge wire. In Fig. 7A, two discharge wires 3d and 3e which are arranged in parallel and separately are wound with a spiral shape and they are constituted by the insulation discharge wire.

When the electric insulation in the space between the two discharge wires is lowered due to the dirty and the water component of the conductive substance such as the oxides of nitrogen and sulfur, the electric resistance between the two wires has become small and as a result the discharge performance is lowered remarkably.

This is that as if an insulation surface of the insulation body 2d which is formed by the alumina etc. containing the heat resistance basicity is presented to be covered with the integral conductive body and the discharge is not occurred easily. To present this, between the two discharge wires the voltage is applied and the electric power is applied and then using the heat or the discharge

it is vaporized and is purified. This can be used as the dirty sensing sensor.

A reference numeral 22d is a conductive body of the insulation core wire and reference numerals 17d and 17e are  
5 insulation bodies of a lead wire portion of the discharge wire.

Fig. 7B shows a side cross-sectional view of the insulation discharge wire of Fig. 7A.

Fig. 7C shows an example in which the insulation  
10 discharge wire is constituted by placing in parallel the discharge wires 3f and 3h and by winding with a spiral shape. The insulation and discharge wire is constituted with a core wire conductive body 22e, insulation body 2e, and a lead wire insulation bodies 17f, 17fg and 17h.

15 The discharge performance of this kind discharge insulation wire is differed extremely according to an arrangement pitch size of the discharge wire. In the insulation body having a discharge wire diameter of 0.3 mm, in a case of a pitch of 10 mm the most discharge  
20 characteristic is attained.

As shown in Table 1, the discharge characteristic is changed largely according to the pitch and the length and it is changed less than of 1/2. Using this phenomenon, the discharge characteristic is changed according to the  
25 combination of the discharge wires and the length of the tap. For example, the pitch is changed, the plural

discharge wires are wound and the connection thereof and the combination are changed and further making the same polarity and selecting them the discharge characteristic is changed.

5 Using the single discharge wire the supply energy is changed and discharge characteristic is changed. By combining the single discharge wire with these plural discharge wires, the control width has been the exhaust gas processing machine is realized to have a further  
10 performance.

Table 1

Conversion Rate (%) from No to NO<sub>2</sub> by Discharge

Length L (mm)      Electric Power P (W)

Pitch (mm)	L = 250 P = 9	L = 500 P = 18	L = 750 P = 27	L = 1000 P = 36
1	37	44	67	51
5	40	65	60	53
10	48	84	64	58
20	51	78	63	46

15

Fig. 7D shows a cross-sectional view of the structure of the insulation body of the insulation core wire. A reference numeral 22f is a core conductive body and  
20 reference numerals 2f and 2g are insulation bodies. The

insulation 2f is constituted with a substance in which to a substance an alumite processing is carried out with a net shape ceramic member and a space of this is buried with another insulation member and with a thin superior insulation performance.

Fig. 7E shows a cross-sectional view of the thin insulation core wire having the high performance in which to the insulation core wire using the nichrome wire 22g having the high heat resistance and the high strength material. To an outer skin of the core wire in which the alumite processing is carried out after it has formed a wire member by covering the alumina 2h and to the core wire an outer portion insulation body 2i is covered.

Fig. 8 is a graph showing the change of the characteristic in a case when the hydrocarbon is mixed with the exhaust gas. In a case where the oxygen concentration having the oxygen concentration 21 % shown in Fig. 5D is mixed with the hydrocarbon having 1000 ppm, it can be admitted that the remarkable reduction of NO<sub>x</sub> is not appeared. This means that the generation of NO<sub>2</sub> is carried out stably. Namely, NO is converted to NO<sub>2</sub> and as the oxidizing agent it is utilized effectively for the oxidation and the removal of the particle substance.

Of course, the concentration of the oxygen and the concentration of the hydrocarbon are controlled organically

and then the processing apparatus having the stable and high performance is realized.

Fig. 8A and Fig. 8B show NO<sub>x</sub> processing characteristics of the cases where the hydrocarbon of 1000 ppm and the oxygen concentration of 10 % and the hydrocarbon of 1000 ppm and the oxygen concentration of 21 % is mixed.

In this case, NO<sub>x</sub> is not removed completely but it is possible to remove NO<sub>x</sub> by combining the above stated technique shown in Fig. 5 in the final process of the processing apparatus.

Fig. 9 shows the exhaust gas apparatus in which, to reserve and not to escape the heat amount generated during the ozone generation and the corona generation according to the heat generation and the discharge when the particle substance is applied the electric power and is burned up, making the adiabatic structure with the ceramic to the outer portion of the apparatus, the inner portion of the apparatus is maintained with the high temperature as possible, it is possible to carry out the reaction and the decomposition with the small energy addition.

Further, a preheat portion is arranged at a vicinity of the engine exhaust port and the combustion temperature of the particle substance is reached to 650 C as possible and then the reaction promotion and the energy saving is attained.

The above stated exhaust gas processing apparatus has been the comparative simple structure in comparison with that of the prior art apparatus and has been the epoch-making gas processing technique which enable to make the harmless performance of the harmful exhaust gas by following the operation condition of the engine etc. and is utilized all fields relating to the decomposition of the gas and the reaction.

This apparatus is utilized effectively to the pollution measure of the automobile, the boiler and the engine and the chemical reaction promotion, the combustion promotion, and the decomposition of the harmful substance.

Further, the discharge portion can be manufactured from the advanced production techniques of the wire and the optical fiber and accordingly the ozone generation apparatus having the high quality, the superior production performance, and the simple structure and the low cost or the corona generating apparatus can be provided.

Further, the electric applying and burn-up apparatus having the low voltage and the very low cost can be applied to the adsorption and decomposition apparatus having combustible substance.

Further, the electric supply and burning-up apparatus having the ammonia is generated independently and when NOx denitration system is taken in the installation type film.

The effects according to the present invention has the excellent effects as the exhaust gas post-processing apparatus such as the automobile and the boiler the performance, the cost performance and the maintenance performance can be solved at a stroke. The main effects are as following:

1. With the simple discharge wire structure, NOx (NO and NO<sub>2</sub>) is decomposed completely, the generation amount of and NO<sub>2</sub> for oxidizing and decomposing the particle substance is controlled freely under the zero condition of NO, and it is followed completely to the decomposition of the particle substance in the exhaust gas.

The catalyst used in this case is not employed almost the noble metal and is oxidized under the low temperature of 300 C and is exhausted with the harmless carbon dioxide.

2. The particle substance is adsorbed to the ceramic filter and the portion necessary for the burning up of the adsorption face is detected by the plural electrodes, with the power supply of the low voltage the particle substance is burned up selectively and electrically and is formed as the carbon dioxide and is formed as the harmless substance.

Accordingly, the apparatus and machine for processing in the on-board real time and having superior maintenance performance is realized.

Further, by the employment of the catalyst, which is not used almost the noble metal and has the low cost



performance, NO<sub>x</sub> is decomposed and by provision of the ammonia generation apparatus independently and by the combination of the superior denitration apparatus, the exhaust gas processing apparatus having the high

5 performance and the low cost structure and the superior maintenance performance is provided.

3. The exhaust gas processing element is constituted with the alumina containing zirconium having the high reliability as the discharge portion and has the wire shape and is simple and strong by forming thin the insulation coating. The discharge wire is formed the conductive body itself, the ceramic wire and the plural discharge wires are formed with the net structure and then the discharge characteristic and the strength performance and the durability performance are increased.

By burdening the catalyst to the ceramic wire and the catalyst action has been, accordingly the excellent exhaust gas processing element having the high efficiency and the low cost performance is provided.